CHAPTER 1

Heating, Ventilation, and Air Conditioning

Learning Objectives

- Describe the evolution of the modern-day air-conditioning system.
- Explain the purpose of the compressor.
- Describe the function of the condenser.
- Explain the key differences between an orifice tube and a thermostatic expansion valve.

- Explain the purpose of a drier.
- Describe the function of the evaporator.
- Explain how the accumulator works and its function.
- Describe the uses for the manifold gauge set.

Learning Objectives *(continued)*

- List the different types of leak detectors and explain their purpose.
- Explain the functions of a vacuum pump.
- Outline the reasons for refrigerant recovery.
- Describe refrigerant recycling.

Learning Objectives *(continued)*

- Explain why antifreeze must be recycled.
- List the advantages of a ventilation system.
- Outline the advantages of using a scan tool.
- Explain why a refrigerant identifier should be used before servicing an air-conditioning system.

Learning Objectives *(continued)*

- We have come a long way in a brief time period regarding the development of climate control systems in modern vehicles.
- A technician must understand what functions a **heating, ventilation, and air conditioning (HVAC)** system performs and how it accomplishes these tasks.

Introduction

- A technician must also recognize the components of a modern HVAC system and the tools required to maintain them.

Introduction *(continued)*

In this chapter, you will learn about:

- The history of the modern HVAC system.
- The purpose of the heating, ventilation, and air-conditioning system.
- The components that make up modern HVAC systems.
- Some of the specialty tools used by technicians in the HVAC field.

System Overview

- People tried to control the temperature of their environment as far as the Egyptian pharaohs.
- In 1884, William Whiteley placed blocks of ice in a tray under a horse carriage and used a fan attached to a wheel to force air inside.
- Later, a bucket of ice in front of a floor vent became the automotive equivalent.

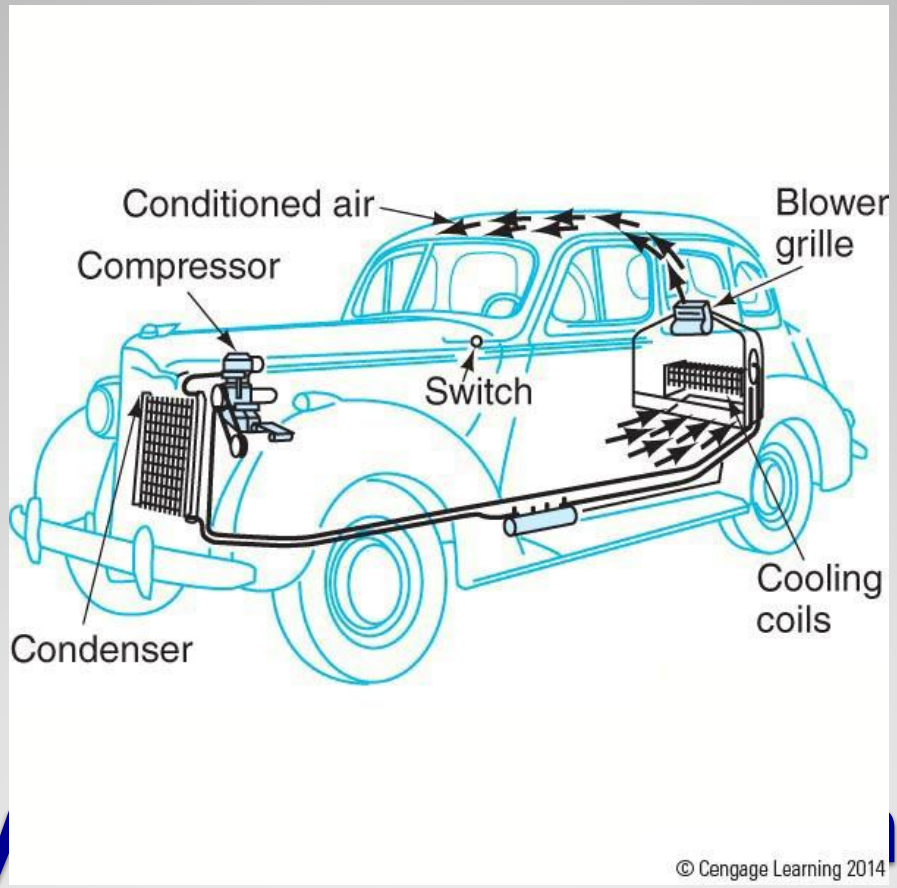
History of Air Conditioning

- Automobiles were not very comfortable for passengers in the early years because the cabins were open.
- Eventually, car companies began to close up the passenger cabins, which required a change in temperature control systems.
- At first, vents were put in the floors of cars, bringing in more dirt and dust than cool air.

History of Air Conditioning *(continued)*

- In 1939, Packard produced the first passenger cars using refrigeration components. A huge evaporator was mounted in the trunk.
- Cadillac introduced an air-conditioned car in 1941.
- In 1954, Delphi Harrison Thermal Systems introduced an air-conditioning system that located all the major components under the car's hood (Figure 1-1).

History of Air Conditioning *(continued)*



History ing (continued)

Figure 1-1. A 1939 Packard with air conditioner.

- Today's vehicles are very comfortable no matter what the weather is like outside.
- Innovations and improvements in overall durability have increased the complexity of today's air-conditioning systems.
- As today's truck drivers travel through different regions, they can enjoy the same comfort levels as they do at home.
- Climate-control systems automatically make the transition from heating to cooling and back.

Today's Air-Conditioning Systems

- For vehicles operating in the northern U.S. or Canada, heating systems keep occupants warm and comfortable and help keep the windshield clear of ice and snow.
- For those operating in the southern U.S. or Canada, air conditioning greatly improves the comfort level of the occupants.
- An added benefit of air conditioning systems is that they remove humidity from the circulating air.

Today's Air-Conditioning Systems *(continued)*

- The "do it yourself" approach to air-conditioning repair is a thing of the past.
- Technicians today must work within stringent environmental regulations.
- The technician must be certified to purchase refrigerant and to repair air-conditioning systems.
- Repair shops must have equipment that can remove all refrigerant from a vehicle to prevent ozone-depleting chemicals from escaping into the air.

Today's Air-Conditioning Systems *(continued)*

- The heat and cold that an HVAC system must overcome originates from many different sources.
- Ambient air temperature and solar radiation are two such sources.
- Tinting of windows can reduce the effects of solar radiation.

Vehicle Heat and Cold Sources

- Other heat sources are those generated by the engine and cooling system. These include transmission heat, exhaust system heat, and heat radiated up through the floor of the vehicle.
- Human body heat and warm moist air from breathing constantly radiate into the air in the cab.
- All add to the heat and moisture that must be removed by an HVAC system (Figure 1-2).

Vehicle Heat and Cold Sources *(continued)*

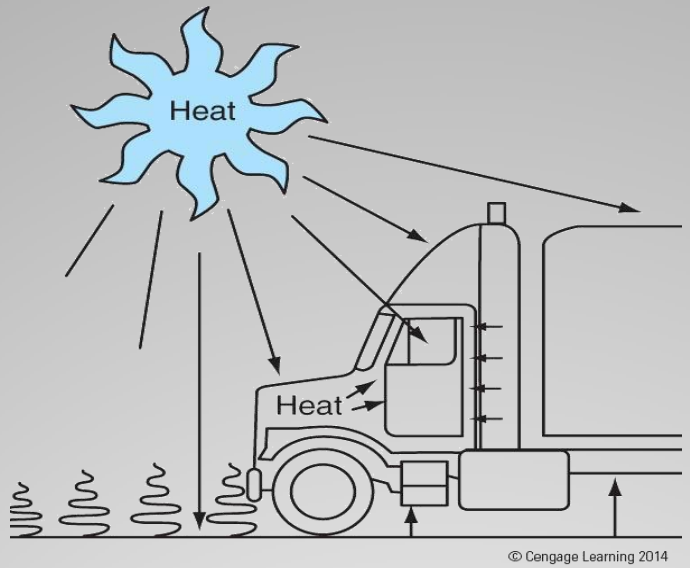


Figure 1-2. Heat enters the cab through windows. Engine heat enters through the firewall, and heat radiates up through the floor of the vehicle.

Vehicle Heat and Cold Sources *(continued)*

Vehicle Heat and Cold Sources *(continued)*

- Another source of hot or cold air is the fresh air **ventilation** system. Air is circulated by a fan, usually referred to as a *blower motor*.
- Outside air coming into the cab must either be heated or cooled before it reaches the vehicle interior.
- The ventilation system improves the performance of the air-conditioning or heating system by improving air flow within the vehicle.

HVAC systems perform three very important functions:

- **Temperature control**. The HVAC maintains the temperature within the passenger compartment as selected by the operator.
- **Humidity control**. The HVAC system reduces the humidity within the passenger compartment.
- **Air circulation control**. The HVAC refreshes the air in the vehicle's interior.

Purpose of the HVAC System

Air-Conditioning Components

The most common components of truck air-conditioning systems are:

1. Compressor
2. Condenser
3. Pressure regulating devices:
    4. Orifice tube
    5. Thermostatic expansion valve
4. Evaporator
5. Receiver-drier
6. Accumulator

- The **compressor** can be referred to as the heart of the HVAC system.
- Compressors are bolted to the engine and are belt-driven by either a V-belt or a serpentine belt.
- The compressor is responsible for compressing and transferring refrigerant gas (Figures 1-3 and 1-4).

Compressor

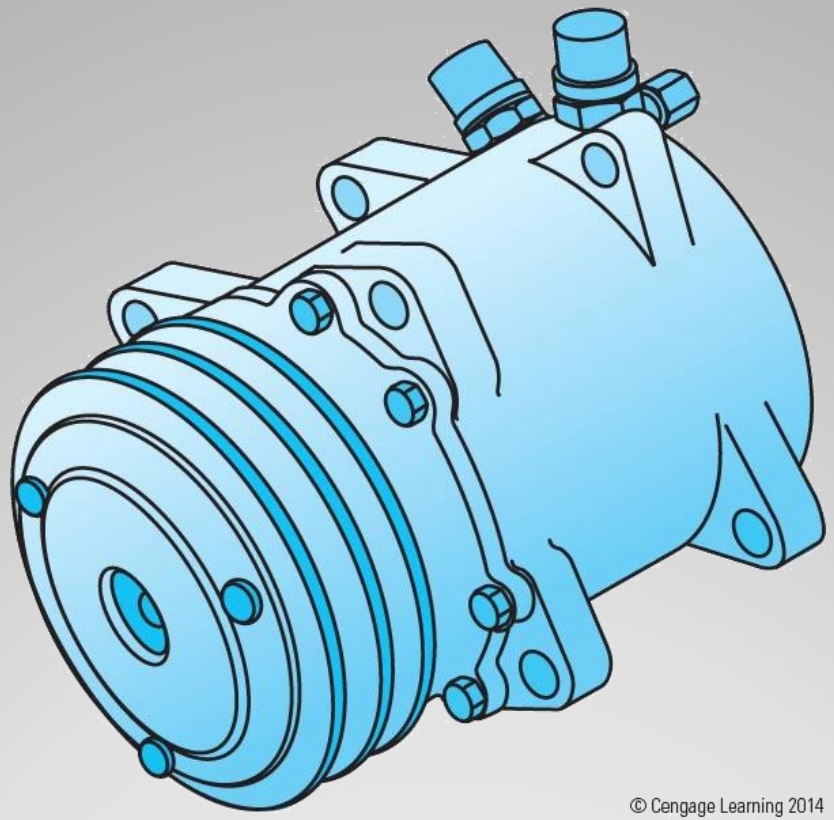


Figure 1-3. Swash plate compressor.

Compressor *(continued)*

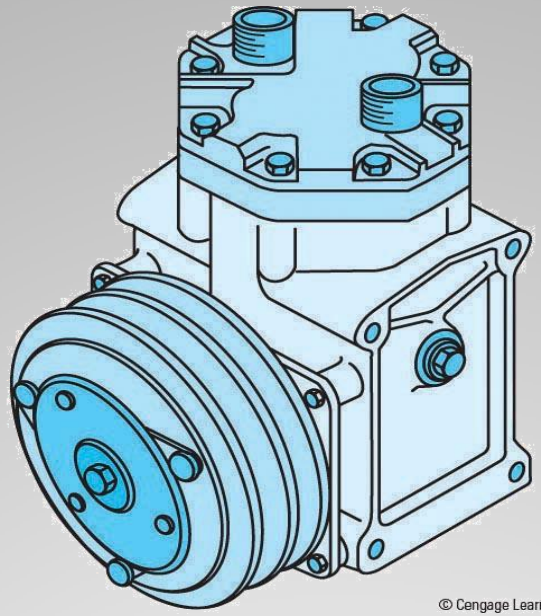


Figure 1-4. Two-piston type compressor.

Compressor *(continued)*

Compressor *(continued)*

- The air-conditioning system may be divided into two different sides: the high-pressure (discharge) side and the low-pressure (suction) side.
- The compressor is the dividing point between the suction and discharge sides of the air-conditioning system.

Compressor *(continued)*

- The suction side of the compressor draws in refrigerant gas from the outlet of the evaporator.
- Once refrigerant is drawn into the suction side, it is compressed, which concentrates the heat in the vapor, raising its temperature.
- The vapor leaving the compressor must be hotter than the atmosphere so that, while it is in the condenser, it will dissipate the heat that it carries to the cooler ambient air.

- The **condenser** dissipates the heat that was once inside the cab of the truck.
- The condenser is designed to radiate heat, and it is usually located in front of the radiator.
- In some retrofit applications, it may be located on the cab roof (Figure 1-5).

Condenser

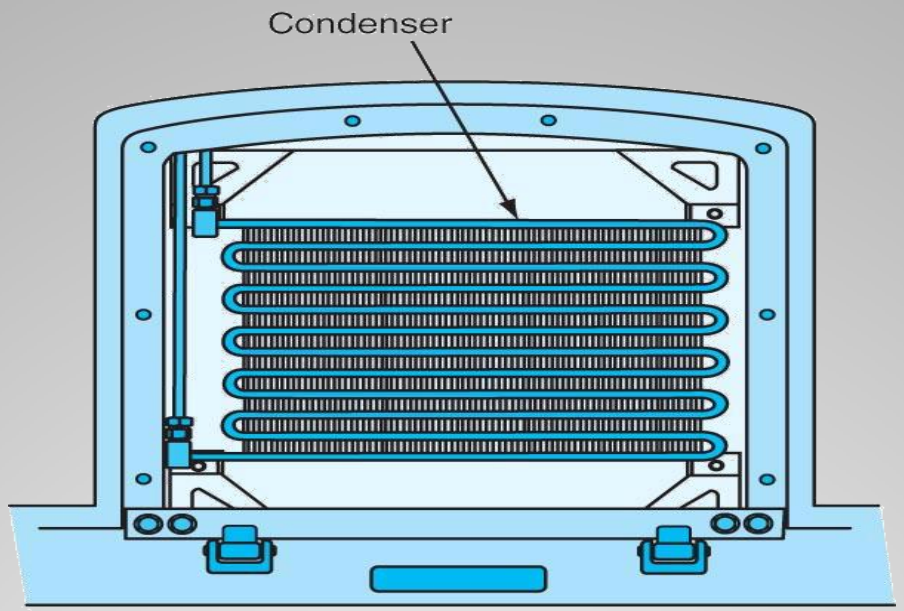


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Figure 1-5. Refrigerant surrenders heat from the cab to the ambient air in the condenser.

Condenser *(continued)*

Condenser *(continued)*

- Condensers must have air flow any time the system is in operation. This is accomplished by the ram air effect or by the engine cooling fan.
- The compressor pumps hot refrigerant gas into the top of the condenser.
- The gas is then cooled and condenses into high-pressure liquid refrigerant at the bottom of the condenser or condenser outlet.

Pressure Regulating Devices

The desired temperature of an evaporator is maintained by controlling refrigerant pressure. Two pressure-regulating devices are:

- **Orifice Tube.** This is a simple restriction located in the liquid line between the condenser outlet and the evaporator inlet (Figure 1-6).
- **Thermostatic Expansion Valve (TXV).** The TXV's job is to regulate the flow of refrigerant so that any liquid refrigerant metered through it has time to evaporate or change states from liquid to gas before leaving the evaporator (Figure 1-7).

Pressure Regulating Devices *(continued)*

Figure 1-6. An orifice tube is used to meter the flow of refrigerant into the evaporator of an orifice tube air-conditioning system.

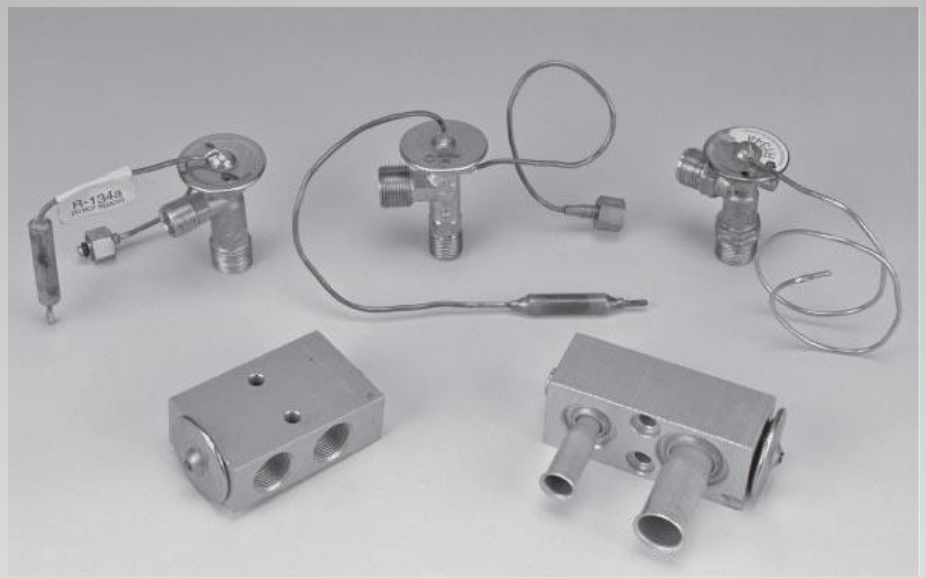


Figure 1-7. An assortment of thermostatic expansion valves.

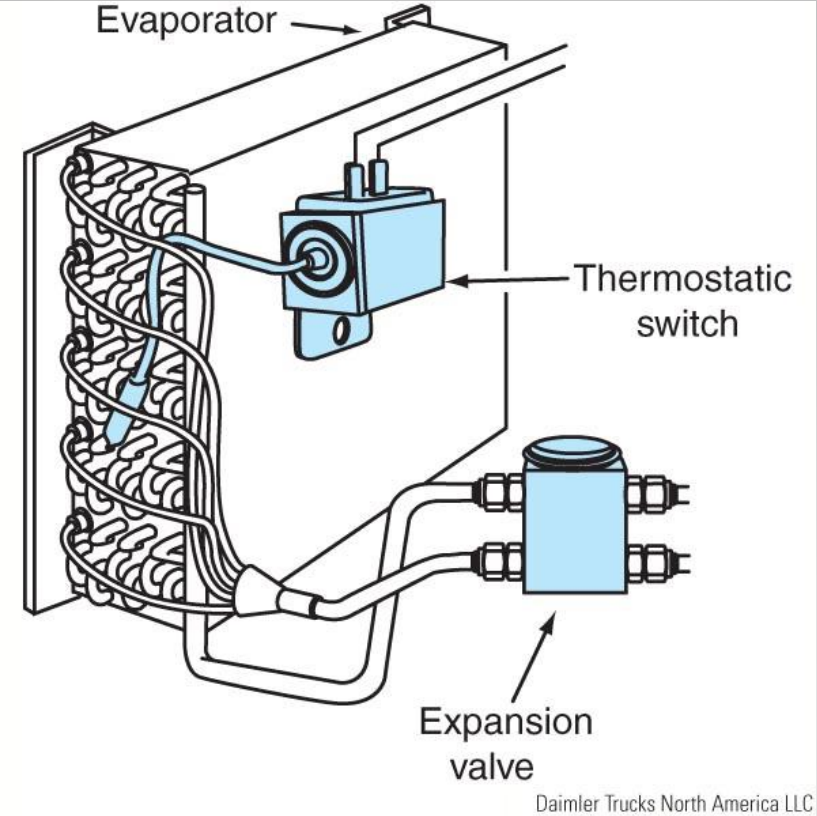
Pressure Regulating Devices *(continued)*

- The **evaporator**'s primary function is to remove heat from within the cab of the vehicle. It is also used for dehumidification.
- It is usually located within the controlled space or is in some way isolated from the outside of the vehicle.
- A blower motor circulates air from the cabin through the evaporator coil.

Evaporator

Evaporator *(continued)*

- As the warmer air travels through the cooler fins of the evaporator, the moisture in the air condenses on their surface.
- In order to keep the evaporator from freezing, several different temperature- or pressure-regulating devices may be used.
- Keeping the evaporator from freezing is extremely important because a frozen evaporator will not absorb very much heat (Figure 1-8).



Evaporator (continued)

Figure 1-8. The evaporator is the component that absorbs heat from the truck's cab.

Evaporator *(continued)*

- Refrigerant enters the evaporator as a low-pressure liquid.
- The refrigerant temperature is lower than that of the air inside the cab, and heat flows from a warm substance to a cooler one.
- The warm air from the cabin passes through the evaporator fins and causes the liquid refrigerant in the evaporator to boil.

Evaporator *(continued)*

- The boiling refrigerant absorbs large quantities of heat from the cabin.
- This heat is then carried off with the refrigerant to the outside of the vehicle.
- The force that draws this low-pressure refrigerant through the evaporator is the suction effect of the compressor.

- The **receiver-drier** is used in air-conditioning systems with a TXV.
- It is used to store refrigerant and separate any gas refrigerant from liquid refrigerant.
- It is a cylindrical metal container usually located on the bulkhead.
- The TXV requires liquid refrigerant to operate efficiently.
- The receiver and desiccant types are chosen for the type of system and refrigerant used within the system (Figure 1-9).

Receiver-Drier

Figure 1-9. The receiver-drier provides storage filtration and moisture removal for passing refrigerant.

Receiver-Drier *(continued)*

- An **accumulator** is used in systems that employ a fixed orifice tube to control the flow of refrigerant into the evaporator.
- The accumulator prevents liquid refrigerant from reaching the compressor.
- It is plumbed into the system between the exit of the evaporator and the inlet of the compressor.
- It also contains a desiccant that removes debris and moisture from the passing refrigerant (Figure 1-10).

Accumulator

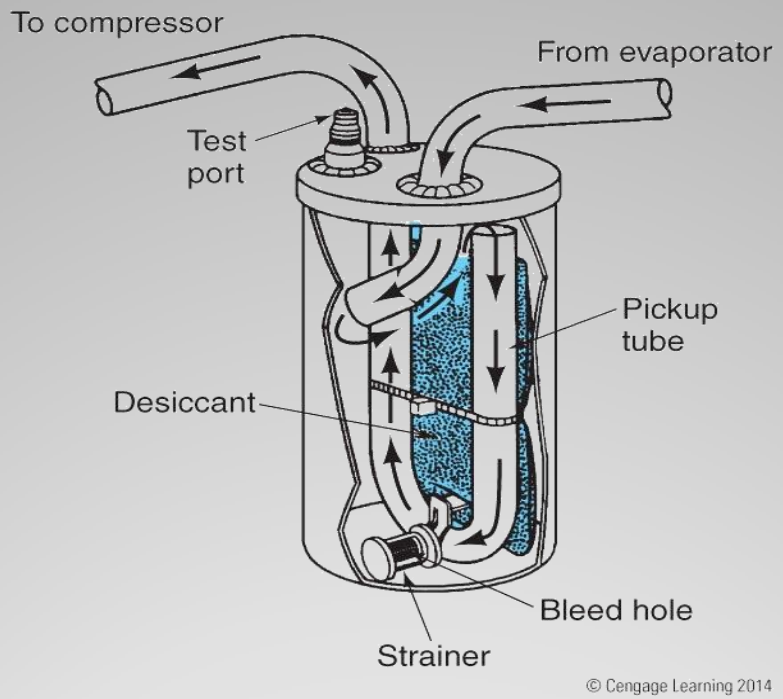


Figure 1-10. The accumulator ensures that only vaporous refrigerant may be returned to the compressor.

Accumulator *(continued)*

- To service air-conditioning systems, technicians must be familiar with the use of tools designed specifically for the mobile air-conditioning field.
- One of the tools that must be mastered by any air-conditioning or refrigeration technician is the *manifold gauge set*.

Special Air-Conditioning Tools

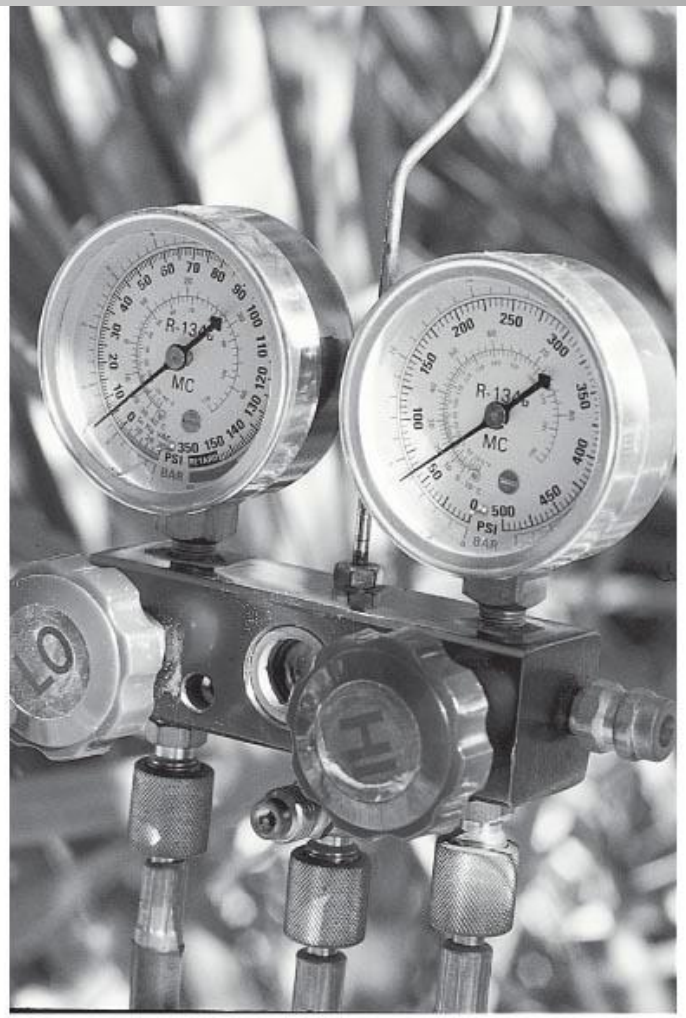
- A technician must be able to read the manifold gauge set and interpret the pressures of the air-conditioning system as it operates.
- These pressures tell the technician if the system is operating correctly or if there is a problem.
- The manifold gauge set is usually the first tool installed on an air-conditioning system before any diagnostic work takes place.

Manifold Gauge Set

Manifold Gauge Set *(continued)*

- A manifold gauge set consists of a manifold block, two hand valves, three refrigerant hoses, and two pressure gauges (Figure 1-11).
- The refrigerant hoses are usually color-coded to indicate where they should be connected.
- The hose on the left is color-coded blue and is connected to the low-pressure/suction side of an air-conditioning system.
- A gauge that reads either vacuum or pressure is connected to the low-pressure hose through the manifold and is also usually blue.

Figure 1-11. A manifold gauge set is probably the technician's best diagnostic tool.



Manifold Gaug

- Because the gauge reads in two different ranges of pressure, it is usually referred to as a *compound gauge*.
- On the vacuum side, the gauge will read to 30 inches of mercury.
- On the positive pressure side, the gauge will read accurately up to 120 psi with a retard section of the gauge reading up to 250 psi.
- Pressures from 120 psi to 250 psi can't be measured accurately, but they will not damage the gauge.

Manifold Gauge Set *(continued)*

- The hose on the right side of the gauge set is color-coded red. It is connected to the high-pressure/ discharge side of the air-conditioning system.
- A gauge that reads in psi or kilopascals is connected to the high-pressure hose through the manifold.
- This gauge is usually red, like the hose to which it is connected.
- The high side is usually calibrated from 0 psig (0 kPa) to 500 psig (3447 kPa).
- This is usually referred to as the *high-pressure gauge*.

Manifold Gauge Set *(continued)*

Safety Eyewear

- Safety eyewear should be worn any time a person enters a shop environment!
- This is especially true when working with refrigerants.
- Full face shields are available for technicians working on air-conditioning systems.
- The safety eyewear worn by the technician should be a type that is approved for working with liquids or gases and must meet ANSIZ87.1-1989 standards (Figure 1-12).

Figure 1-12. Safety eyewear, glasses, goggles, or shields should be worn by everyone entering the shop.

Safety Eyewear

- The purpose of a **leak detector** is to determine the origin of a refrigerant leak.
- Special tools are required to find refrigerant leaks because often the gas will escape, leaving no visible trace as to where it exited the system (Figure 1-13).

Leak Detectors

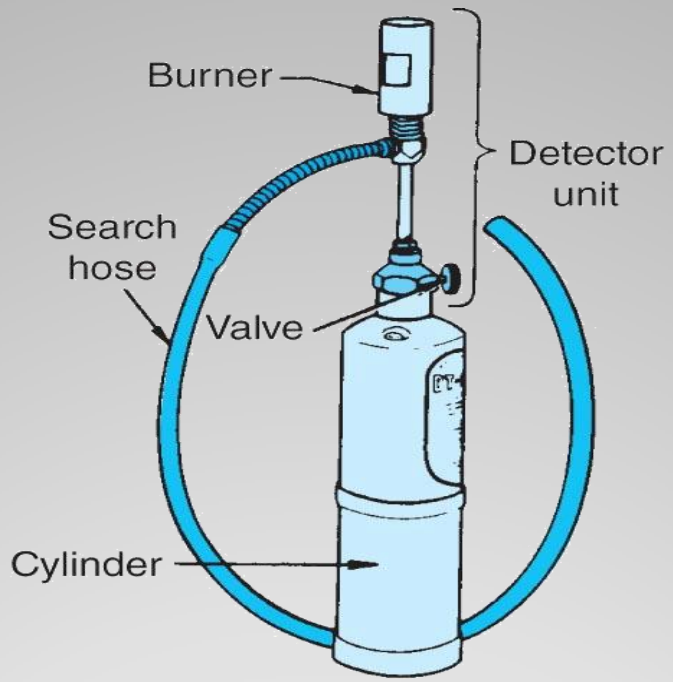


Figure 1-13. A flame-type leak detector used to identify refrigerant leaks.

Leak Detectors *(continued)*

Leak Detectors *(continued)*

- Many different leak detectors are available to find the refrigerant leaks.
- Electronic leak detectors are extremely sensitive.
- These units are capable of detecting leaks as small as 0.5 oz (14 ml) per year.
- Electronic leak detectors are called *halogen leak detectors* and may be used to test for refrigerant leaks with HFC-134a.

Leak Detectors *(continued)*

- Another style of leak detector uses fluorescent dye (Figure 1-14).
- The dye is injected into the system, mixes with the refrigerant and oil, and is circulated throughout the system by the compressor.
- When refrigerant leaks, it pushes out some compressor oil and some of the dye.
- An ultraviolet lamp is used to cause the dye to fluoresce and indicate the source of the leak.

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Figure 1-14. Electronic refrigerant leak detector for finding very small leaks.

Leak Detectors *(continued)*

Leak Detectors *(continued)*

- One other way of finding refrigerant leaks is to listen for them with an ultrasonic tester.
- Ultrasonic testers are able to detect sounds in the ultrasonic frequency that can't be heard by the human ear.
- The detector then converts and amplifies the sound so that the technician can hear it using a head set.
- Some detectors will also display the sound/leak rate (Figure 1-15).

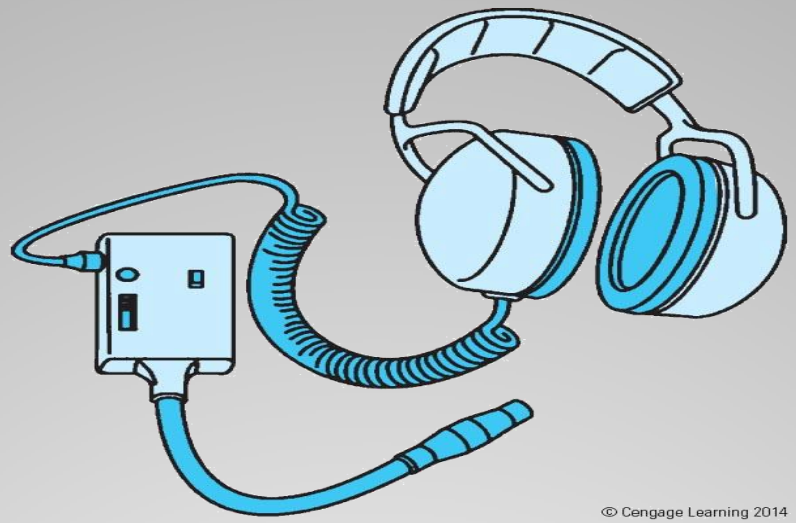

Figure 1-15. Ultrasonic leak detectors allow the technician to hear the refrigerant leak in the ultrasonic range.

Leak Detectors *(continued)*

Thermometers

- A **thermometer** is used by the technician to measure temperatures throughout the air-conditioning system (Figure 1-16).
- The temperature range of the thermometer should be between 0°F and 220°F (–18°C and 104°C).
- When accuracy is the main concern, an electronic thermometer may be required.
- Infrared temperature guns are used to measure radiator temperatures, coolant lines, and engine operating temperatures.

Figure 1-16. Thermometers are used to make accurate diagnoses of air-conditioning systems.

Thermometers *(continued)*

- Technicians require the use of some expensive tools that are generally supplied by the shop.
- Some of these tools are: a vacuum pump, refrigerant recovery and recycling system, antifreeze recovery and recycling system, electronic scale, refrigerant identifier, and electronic thermometer.
- There are also scan tools used for diagnosis of the automatic temperature control system and specialty tools required for compressor service.

Shop Specialty Tools

- A **vacuum pump** is used to remove moisture and air from a system that has been opened for service or when a leak has been repaired in it (Figure 1-17).
- Removing air and moisture that has entered the air-conditioning system is called *evacuation*.
- If left in the system, air will cause higher than normal pressures and carbonizing of the compressor oil.
- If moisture is left in the system, it will mix with the oil, causing acids to form in the system.

Vacuum Pump

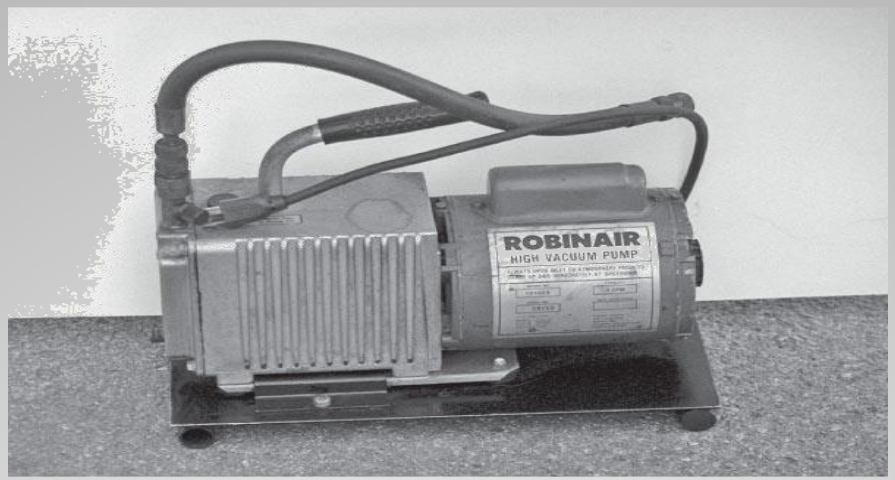

Figure 1-17. A vacuum pump is used to remove air, moisture, and impurities from the air-conditioning system.

Vacuum Pump *(continued)*

- Shops that service air-conditioning equipment must have **recovery** and **recycling** equipment so that refrigerant is not released into the atmosphere (Figure 1-18).
- The equipment does this by circulating the refrigerant through replaceable filter and drier elements that remove contaminants and moisture.
- Recovery and recycling equipment is generally dedicated to one type of refrigerant to prevent cross-contamination of refrigerant.

Refrigerant Recovery and Recycling Equipment

Figure 1-18. A recovery/recycling refrigerant machine removes refrigerant from the system and recycles the refrigerant for reuse.

Refrigerant Recovery and Recycling Equipment *(continued)*

Antifreeze Recovery and Recycling Equipment

- The mixture of antifreeze and water in a vehicle's cooling system will eventually need to be replaced.
- Over time, the corrosion-inhibiting additives are gradually used up and the coolant loses its ability to protect the metal parts within the cooling system.
- The main ingredient in antifreeze (ethylene glycol) never wears out and can be recycled.
- Many shops use recovery/recycling equipment to avoid the high cost of disposing of their used antifreeze (Figure 1-19).

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Figure 1-19. An antifreeze recovery machine is used to recycle antifreeze so that it can be reused in the engine cooling system.

Antifreeze Recovery and Recycling Equipment *(continued)*

- Electronic weigh scales are used to dispense refrigerant accurately by weight.
- Accuracy is important because too much refrigerant in the system creates high compressor discharge pressures, and too little refrigerant creates low compressor suction and discharge pressure and insufficient cooling (Figure 1-20).

Electronic Weigh Scales

Figure 1-20. A portable electric scale is used by technicians to weigh in the correct refrigerant charge accurately.

Electronic Weigh Scales *(continued)*

- **Scan tools** are used to improve troubleshooting capabilities, allowing the technician to get to the origin of a problem accurately.
- These tools can display trouble codes for the technician, and some of the more highly sophisticated tools will allow the technician to monitor and view sensor and computer information (Figure 1-21).
- This allows the technician to pinpoint a heating, ventilation, or air-conditioning (HVAC) problem.

Scan Tools/ Onboard Diagnostics

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Figure 1-21. A scan tool is used to improve the technician's trouble-shooting capabilities.

Scan Tools/Onboard Diagnostics *(continued)*

- A **refrigerant identifier** is used to determine the contents of an air-conditioning system.
- It is important to know what type of refrigerant is in a system so that cross-contamination within a recovery machine can be prevented.
- The identifier should be used whenever the technician is not certain of the contents of an air-conditioning/refrigeration system (Figure 1-22).

Refrigerant Identifier

Figure 1-22. A refrigerant identifier is used to test the type and purity of refrigerant within the system.

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Refrigerant Identifier *(continued)*

CAUTION

If the sample contains a flammable hydrocarbon, it should not be serviced unless extreme care is taken to prevent serious personal injury.

- Compressor servicing tools are used to remove the compressor's electromagnetic clutch assembly and to remove and replace the compressor's rotary front drive shaft seal.
- These tools are usually quite compact so that the technician can service the compressor without having to remove it from the vehicle.

Compressor Servicing Tools

- The compressor is responsible for compressing and transferring refrigerant gas.
- The condenser dissipates the heat that was once inside the cab of the truck.
- The orifice tube is a simple restriction in the liquid line between the condenser outlet and evaporator inlet.
- The expansion valve regulates the flow of refrigerant so that any refrigerant metered through it has time to evaporate or change states from liquid to gas before it leaves the evaporator.

Summary

- The evaporator's primary function is to remove heat from within the cab of the vehicle.
- The receiver-drier is used to store refrigerant and separate any gas refrigerant from liquid refrigerant.
- The main purpose of the accumulator is to prevent liquid refrigerant from reaching the compressor.
- Technicians use the manifold gauge set to measure the operating pressures of an air-conditioning system.
- Leak detectors are used to pinpoint refrigerant leaks within the air-conditioning system.

Summary *(continued)*

- The vacuum pump is used to remove moisture and air that can enter the system.
- Recovery machines are used to remove the entire refrigerant charge from an air-conditioning system.
- Recycling machines are used to clean used refrigerant.
- Scan tools allow the technician to troubleshoot an HVAC system accurately.
- Refrigerant identifiers are used to determine the type and purity of the refrigerant in the system.

Summary *(continued)*